J. Glob. Innov. Agric. Soc. Sci., 2014, 2(3): 107-111.
ISSN (Online): 2311-3839; ISSN (Print): 2312-5225
DOI: 10.17957/JGIASS/2.3.563
http://www.jgiass.com

PERFORMANCE OF AUTUMN PLANTED MAIZE HYBRIDS UNDER DIFFERENT FERTILIZER TREATMENTS IN SEMI-ARID PUNJAB-PAKISTAN

Khalid Rehman[1*], Saif Ali[1], Muhammad Wajid Pervez[2], Muzammal Rehman[1], Saddam Hussain[3], Ghulam Aishia[3] and Muhammad Shahzad Khalid[1]

[1]Department of Agronomy, University of Agriculture, Faisalabad, Pakistan
[2]Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad, Pakistan
[3]College of Plant Science and Technology, Huazhong Agricultural University, Wuhan, Hubei 430070, China
[*]Corresponding author's e-mail: paragon2086@yahoo.com

Optimizing the fertilizer rates is necessary to achieve optimal yield potential of a cultivar. A study was carried out to evaluate the effect of different NPK fertilizer rates on the growth and yield of two maize hybrids during autumn season, 2012 in agro-ecological conditions of Faisalabad, Punjab-Pakistan. Two maize hybrids namely Monsanto-6789 and Pioneer- 30Y87 were tested using different fertilizer rates viz., F_1 (200:100:90 kg NPK ha^{-1}), F_2 (250:125:110 kg NPK ha^{-1}), F_3 (300:150:130 kg NPK ha^{-1}) and F_4 (350:175:150 kg NPK ha^{-1}). Treatments were arranged in randomized complete block design under factorial arrangement replicated thrice. Results revealed that increasing the level of fertilizer up till F_3 enhanced the crop yield and its related attributes. Maximum 1000-grains weight (255.4 g), grain yield (6.9 t ha^{-1}) and biological yield (20.97 t ha^{-1}) were observed in F_3 (300:150:130 kg NPK ha^{-1}). Whereas, among different hybrids, Pioneer-30Y87 outperformed Monsanto-6789 regarding number of grain rows per cob, cob diameter, grains per cob, 1000-grains weight and grain yield. On interactive basis, Pioneer-30Y87× F_3 proved the best combination regarding all studied attributes. Furthermore, highest economic net benefits were also associated with the same treatment combination. Conclusively, of the factors included in this study, maize hybrids and NPK fertilization treatments were dominant in determining grain yield as well as its related components, suggesting that cultivar selection and optimum fertilization are effective strategies to improve grain yield. However, multi-location and multi-year studies are required to test these results using different cultivars under varying soil and climatic conditions.
Keywords: NPK fertilizer rates, growth, yield, maize hybrids

INTRODUCTION

Maize (*Zea mays* L.) is an important cereal crop worldwide having great economic value. It is used as food for human consumption and fodder, forage and silage for livestock (Harris et al., 2007; Fahad et al., 2014a). It is grown on an area of 9.39 million hectares in Pakistan with annual production of 4.27 million tons and average yield 3.56 ton ha^{-1} (GOP, 2010). In Pakistan, national average yield of maize is extremely low as compared to developed countries, and imbalanced supply of nutrients is considered as one of the major cause of yield reduction (Fahad et al., 2014b, Khan et al., 2014). Maize is anatomically C4 plant, therefore, its growth rate and production of dry matter is higher than to wheat (Oaks, 1994). Maize is an important source of edible oil. Starch is the main product of maize from which dextrin, liquid glucose, solid glucose, powder glucose and crystalline dextrose are prepared (Masood et al., 2011; Eltelib et al., 2006). Worldwide, maize starch is also used for the production of biofuel (as ethanol) after fermentation (Ahmad et al., 2007). Maize grain contains 72% starch, 5.8% fiber, 3.0% sugar, 10% protein, 4.8% oil and 1.7% ash (Hussain et al., 2007).

Nitrogen plays an important role in plant growth processes because nitrogen is integral part of chlorophyll. Nitrogen is main constituent of many enzymes, nucleic acid and many proteins. Therefore, nitrogen in excess or deficiency reduced the yield of maize (Sharifi and Taghizadeh, 2009; Khan et al., 2014). Nitrogen application not only increases the yield of maize but also improves the protein contents of maize crop (Khandaker and Islam, 1988). Deficiency of nitrogen results in low plant growth which reduces the grain yield, leaf area index, leaf area duration and rate of photosynthesis. It imparts dark green color to plants (Mahmood *et al.,* 2001; Khan *et al.,* 2014).

Phosphorus is important for yielding capacity, protoplasm formation and it influences the quantity of available nitrogen to plant. Phosphorus is essential for inflorescence, grain formation, ripening and reproductive parts of maize plant (Ibrahim and Kandil, 2007). It is needed for growth, nucleus formation, photosynthesis, utilization of sugar and starch, cell division and fat and albumen formation. Phosphorus is readily translocated within the plants and it moves from older tissues to younger tissues (Ali et al., 2002). Phosphorus in adequate amount is necessary for earlier maturity, rapid growth and improves the quality of vegetative growth. Deficiency of Phosphorus is responsible

for small ears in maize due to crooked and missing rows as kernel twist (Rashid and Memon, 2001).

Potassium also plays pivotal role for synthesis of carbohydrates and protein in plants and it is essential for activation of many enzymes (Tisdale et al., 1990). Maize hybrids exhibited different response to application of potassium due to difference in uptake, utilization, translocation, accumulation and growth (Minjian et al., 2007). Optimum and balanced use of NPK fertilizer increased the yield of maize, therefore, proper dosage of NPK is of prime importance (Asghar et al., 2010).

Cultivars differ in their response to nutrient supply and when planted in different geographical environments (Grant et al. 2008). Optimizing the NPK fertilizer doses is necessary to achieve optimal yield potential of a cultivar. The present study was therefore, devised to evaluate the response of potentially high yielding cultivars Monsanto-6789 and Pioneer-30Y87 of maize to different rates of NPK fertilizer during autumn season under the agro climatic condition of Faisalabad.

MATERIALS AND METHODS

Site description : A field experiment, to analyze the effect of different NPK fertilizer rates on growth and yield of maize hybrids (*Zea mays* L.) was conducted during the 2012 (autumn season) at Agronomic Research Area, University of Agriculture, Faisalabad, Pakistan (31.25° N, 73.09° E, and 184 m above sea level). Due to high evapotranspiration, Faisalabad features a semi-arid climate with mean annual rainfall of about 200 mm. Pre-sowing soil samples were collected from experimental area with the help of a soil auger to a depth of 0-30 cm and then air dried for physico-chemical analysis. The soil of the experimental site was a sandy clay loam with proportion of sand, silt and clay as 55.25, 19.55 and 25.20%. Soil pH and EC was 7.9 and 0.89 dSm^{-1}, respectively. The organic matter, total nitrogen, available phosphorus and potassium were 0.69%, 0.062%, 17 mg kg^{-1} and 179 mg kg^{-1}, respectively. The Bulk density and cation exchange capacity was 1.42 g CC^{-1} and 4.3 cmolc kg^{-1}.

Experimentation: The two factor experiment was laid out in randomized complete block design under factorial arrangement of treatments. It was comprised of three replications with a net plot size of 6.0 m × 3.0 m. Maize hybrids Monsanto-6789 and Pioneer-30Y87 were sown on 3rd August, 2012 by using standard procedures. Crop was manually sown in rows with 75 cm row spacing and 25 cm plant spacing using seed rate of 30 kg ha^{-1}. The plant population was maintained at 65 thousand plants per hectare, manually. At four leaves stage, thinning was performed to adjust the population to desired level. Urea, Diammonium phosphate (DAP) and Potassium sulphate (SOP) fertilizers were used for the sources of N, P and K, respectively. Whole quantity of P and K was applied prior to seeding as basal dose while N was applied in three splits (1/3rd at the time of sowing, 1/3rd at five leaf stage and 1/3rd at tasseling stage). Carbofuron (Furadan 3-G) @6 kg ha^{-1} was applied after thinning of crop at 3-4 leaf stage to protect the crop from maize borer and shoot fly (*Ostrinia* and *Atherigonasoccata*). Two maize hybrids viz., Monsanto-6789 and Pioneer-30Y87 were tested under different NPK levels viz., F_1 (200:100:90 kg NPK ha^{-1}), F_2 (250:125:110 kg NPK ha^{-1}), F_3 (300:150:130 kg NPK ha^{-1}) and F_4 (350:175:150 kg NPK ha^{-1}).

Data Collection: For recording grain weight per cob, five cobs were selected at random from each plot and grain weight per cob was recorded and averaged. Number of grains per cob, were determined by taking ten cobs at random from each plot and counted their grains and then averaged. 1000-grain weight was calculated by taking five cobs at random from each plot and then counted the thousand grains by seed counter and then took 1000-grain weight. Grain pith ratio was obtained by taking ten plants at random from each plot and then took grain weight and pith weight. Grain weight was divided by pith weight for estimation of grain pith ratio. For obtaining grain yield, cobs of all the plants from each net plot were sun dried and shelled with a mechanical sheller to obtain the grain yield. The produce was weighed using a spring balance and converted into t ha^{-1}. Biological yield was determined by taking weight of sun dried bundles with the help of spring balance and then yield on hectare basis was calculated. Net field benefits were calculated by subtracting the total cost from the total benefits of each treatment combination. Input and output cost for each treatment combination was converted into Rs. ha^{-1}.

Statistical analysis: Analyses of variance were performed with all data to confirm variability of data and validity of results. The differences amongst treatments were separated using least significance difference test at 0.05 probability level.

RESULTS AND DISCUSSION

The main as well as the interactive effect of hybrids and different levels of NPK fertilizer on grain weight per cob was significant ($p \leq 0.05$). Maximum grain weight per cob (142.3 g) was obtained for Pioneer 30Y87 hybrid which was fertilized at 300:150:130 kg NPK ha^{-1} (Table 1). Monsanto-6789 fertilized at 300:150:130 kg NPK ha^{-1} recorded the grain weight per cob of 131.3 g (Table 1). Minimum grain weight per cob (112.0 g) was recorded for Monsanto-6789 hybrid, when it was fertilized with 200:100:90 kg NPK ha^{-1}. Nutrient stress at lower fertilizer levels might have reduced the resource partitioning for cob so less grain weight per cob was produced. These results are in line with Ashfaq (2004).

Significant ($P \leq 0.05$) influence of maize hybrids and different levels of NPK fertilizer on 1000-grain weight was observed. Maximum 1000 grain weight (265.4 g) was obtained in for Pioneer 30Y87 hybrid which was fertilized at 300:150:130 kg NPK ha^{-1} (Table 1). It was followed by Pioneer 30Y87 fertilized at 350:175:150 kg NPK ha^{-1} giving

Table 1: Influence of different NPK fertilizer levels on the crop yield and related attributes of maize hybrids

Varieties	No. of grains cob^{-1}	Grains/cob	1000-grain wt. (g)	Grain pith ratio	Grain yield (t ha^{-1})	Biological yield (t ha^{-1})
Varieties						
V_1 (Monsanto- 6789)	121.7 b	531.3 b	238.7 b	2.89 b	5.60 b	17.79 b
V_2 (Pioneer- 30Y87)	127.7 a	537.20 a	250.07 a	3.09 a	5.89 a	18.24 a
LSD (p≤0.05)	1.15	5.79	3.72	0.13	0.11	0.19
Fertilizer levels						
F_1 (200:100:90 kg ha^{-1})	116.0 c	462.73 d	229.40 c	2.48 d	4.63 d	16.07 d
F_2 (250:125:110 kg ha^{-1})	123.2 b	529.17 c	245.17 b	2.78 c	5.62 c	17.25 c
F_3(300:150:130 kg ha^{-1})	136.8 a	596.67 a	255.44 a	3.55 a	6.84 a	20.47a
F_4(350:175:150 kg ha^{-1})	122.7 b	548.50 b	247.52 b	3.15 b	5.90 b	18.28 b
LSD (p≤0.05)	1.62	8.18	5.25	0.18	0.15	0.27
Interaction (FxV)						
F1×V1	112.0 f	474.0 f	225.3 e	2.23 e	4.58 f	15.97 e
F2×V1	121.0 d	523.3 e	242.3 c	2.80 d	5.47 e	17.10 d
F3×V1	131.3 b	587.6 b	245.4 c	2.43 ab	6.72 b	19.97 b
F4×V1	120.7 d	540.33d	241.6 c	3.10 c	5.63 de	18.13 c
F1×V2	117.0 e	551.4 g	233.4 d	2.73 d	4.68 f	16.17 e
F2×V2	125.3 c	535.0 d	248.0 bc	2.77 d	5.77 d	17.40 d
F3×V2	142.3 a	605.6 a	265.4 a	3.67 a	6.95 a	20.97 a
F4×V2	124.7 c	556.6 c	253.3 b	3.20 b	6.17 c	18.43 c
LSD (P≤0.05)	3.43	11.58	7.43	0.26 c	0.21	0.39

Any two means not sharing a letter in common differ significantly at P≤0.05

Table 2: Economic analysis of different fertilizer treatments and cultivars

Treatment	Yield (t ha^{-1})	Value (Rs. ha^{-1})	Straw yield (t ha^{-1})	Value (Rs. ha^{-1})	Gross income (Rs.ha^{-1})	Total cost (Rs. ha^{-1})	Net return (Rs.ha^{-1})	Benefit cost ratio
F1×V1	4.58	137400	11.39	14807	152207	120477	31730	1.26
F2×V1	5.47	164100	11.63	15119	179219	133922	45297	1.34
F3×V1	6.72	201600	13.25	17225	218825	148453	70372	1.47
F4×V1	5.63	198900	12.5	16250	215150	156372	58778	1.37
F1×V2	4.68	140400	11.49	14937	155337	121712	33625	1.28
F2×V2	5.77	173100	11.63	15119	188219	135647	52572	1.39
F3×V2	6.95	208500	14.02	18226	226726	149986	76740	1.51
F4×V2	6.17	185100	12.31	16003	201103	158758	42345	1.27

Price of grain yield (t ha^{-1}) = Rs. 30,000/-; Price of straw yield (t ha^{-1}) = Rs. 1300/-

1000-grain weight of 253.3 g. Minimum 1000-grain weight (225.3 g) was recorded in case of Monsanto-6789 hybrid, when NPK was applied at 200:100:90 kg ha^{-1} (Table 1). Decline in the availability of resources at low fertilizer levels may have adversely affected the efficiency of plants to convert intercepted radiation into grain sink capacity as competition for photosynthesis, which resulted in less 1000-grain weight. These results are in confirmation with Maqsood *et al*. (2001).

Data regarding number of grains per cob and grain pith ratio revealed significant influence of maize hybrids and different levels of NPK fertilizer on this parameter (Table 1). Maximum number of grains per cob (605.6) and grain pith ratio (3.67) was obtained in case of Pioneer 30Y87 hybrid which was fertilized at 300:150:130 kg NPK ha^{-1}. It was followed by Monsanto 6789 fertilized at 300-150-130 kg NPK ha^{-1} giving number of grains per cob of 587.6. Pioneer 30Y87 fertilized at 350:175:150 kg NPK ha^{-1} giving grain pith ratio of 3.20. Minimum grains per cob (474.0) and grain pith ratio (2.23) were recorded in case of Monsanto-6789 hybrid, when NPK was applied at 200:100:90 kg ha^{-1}. Higher number of grains per cob and rain pith ratio in fertilized plots might be attributed to proper nutrient supply in these plots. Similar results were also recorded by Maqsood *et al*. (2001) and Oktem and Oktem (2005).

Biological yield is the total biomass produced by a crop from a unit area. The main as well as interactive effect of hybrids and different levels of NPK fertilizer on biological yield was significant ($p \leq 0.05$). Maximum biological yield (20.97 t ha^{-1}) was obtained in case of Pioneer 30Y87 hybrid which was fertilized at 300:150:130 kg NPK ha^{-1}. It was followed by Pioneer 30Y87 fertilized at 350:175:150 kg NPK ha^{-1} giving biological yield of 19.97 t ha^{-1}. Minimum biological yield (15.96 t ha^{-1}) was recorded in case of Monsanto-6789 hybrid fertilized at 200-100-90 kg NPK ha^{-1} (Table 1). Higher biological yield in fertilized plots is attributed to more plant height, number of grains per cob, and 1000-grain weight in these plots. These results are supported by Deksissa *et al*. (2008) and Ogbaji (2003).

Grain yield is the most important parameter and ultimate mission of farmers. The main as well as interactive effect of hybrids and different levels of NPK fertilizer on grain yield was significant. Maximum grain yield (6.95 t ha^{-1}) as indicated in table 1, was obtained in case of Pioneer 30Y87 hybrid which was fertilized at 300:150:130 kg NPK ha^{-1}. It was followed by Pioneer 30Y87 fertilized at 350:175:150 kg

NPK ha^{-1} giving grain yield of 6.72 t ha^{-1}. Minimum grain yield (4.58 t ha^{-1}) as shown in table 1 was recorded in case of Monsanto-6789 hybrid when 200:100:90 kg NPK ha^{-1} was applied. Lower fertilization may be disturbed the source and sink relationship due to stress prevailing among the plants. Fertilized maize crop resulted in more number of grains per cob, and higher 1000-grain weight, ultimately higher grain yield. These results were supported by Sharar *et al*. (2003).

The economic analysis of data (Table 2) depicted that the maximum net income (Rs. 70372) was found in maize hybrid Pioneer-30Y87 which was fertilized at 300:150:130 kg NPK ha^{-1}, while minimum net income (Rs. 31730) was recorded in Monsanto- 6789 when 200:100:90 kg NPK ha^{-1} was applied. Maize hybrid Pioneer-30Y87 gave maximum benefit cost ratio (1.51) in the plots which were fertilized at 300: 150:130 kg NPK ha^{-1} while minimum value (1.26) was found in Monsanto-6789 which was fertilized at 200:100:90 kg NPK ha^{-1} (Table 2).

CONCLUSION

In crux, of the factors included in this study, maize hybrids and NPK fertilization treatments were dominant in determining grain yield as well as its related components, suggesting that cultivar selection and optimum fertilization are effective strategies to improve grain yield. Variations were apparent in hybrids, and Pioneer 30Y87 outperformed Monsanto-6789 regarding all studied attributes. Among different NPK application level, 300:150:130 kg NPK ha^{-1} led to better performance of maize hybrids and also resulted higher benefit cost ratio under agro-ecological condition of Faisalabad, Pakistan. Future work may focus on screening/breeding of highly nutrient response cultivars. Furthermore, these results may be tested under varying soil and climatic conditions in further studies.

REFERENCES

Ahmad, M., R. Ahmad and A. Rehman. 2007. Crowding stress tolerance in maize hybrids. Economic and Business Review. The Daily Dawn, Lahore, Pakistan. pp: 17-22.

Ali, J., J. Bakht, M. Shafi, S. Khan and W.A. Shah. 2002. Effect of N and P on yield components of maize. Pak. J. Agron. 1: 12-14.

Asghar, A., A. Ali, W.H. Syed, M. Asif, T. Khaliq and A.A. Abid. 2010. Growth and yield of maize (*Zea mays* L.) cultivars affected by NPK application in different proportion. Pak. J. Sci., 62: 211-216.

Ashfaq, M. 2004. Influence of different rates of nitrogen and phosphorus on growth and yield of two maize varieties. M.Sc. (Hons.) Thesis, Depart of Agronomy, Uni. Agri. Faisalabad, Pakistan.

Ayub, M., M.A. Nadeem, M.S. Sharar and N. Mahmood. 2002. Response of maize (*Zea mays* L.) fodder to different levels of nitrogen and phosphorus. Asian J. Plant Sci. 1: 352-354.

Deksissa, T., I. Short and J. Allen. 2008. Effect of soil amendment with compost on growth and water use efficiency of Amaranth. Int. Proc. of the UCOWR/ NIWR Annual Conf. Int. Water Res. Challenges for the 21st Century and Water Resources Education, Durham, NC.

Eltelib, H.A., M.A. Hamad and E.E. Ali. 2006. The effect of Nitrogen and Phosphorus fertilization on growth, yield and quality of forage maize (*Zea mays* L.) J. Agron. 5: 515-518.

Fahad, S., S. Hussain, S. Saud, S. Hassan, H. Muhammad, D. Shan, C. Chen, C. Wu, D. Xiong, S. B. Khan, A. Jan, K. Cui, J. Huang. 2014. Consequences of narrow crop row spacing and delayed *Echinochloa colona* and *Trianthema portulacastrum* emergence for weed growth and crop yield loss in maize. Weed Res. DOI: 10.1111/wre.12104.

Fahad, S., S. Saud, S. Hussain, S. Hassan, Y. Chen, N. Deng, F. Khan, C. Wu, W. Wu, F. Shah, B. Ullah, J. Huang. 2014. Grain cadmium and zinc concentrations in maize as influenced by genotypic variations and zinc fertilization. Clean-Soil, air, water. In press.

Govt. of Pakistan. 2010. Agricultural statistics of Pakistan 2009-10, Govt. of Pakistan, Ministry of food, Agriculture and livestock, economic wing. Islamabad, Pakistan.

Grant CA, Clarke JM, Duguid S, Chaney RL, 2008. Selection and breeding of plant cultivars to minimize cadmium accumulation. Sci. Total Environ. 390: 301-310.

Harris D, Rashid A, Miraj G, Arif M, Shah H, 2007. On-farm seed priming with zinc sulphate solution–A cost-effective way to increase the maize yields of resource-poor farmers. Field Crop Res. 110: 119-127.

Hussain N, Khan AZ, Akbar H, Bangash NG, Khan ZH, Idrees M, 2007. Response of maize varieties to phosphorus and potassium levels. Sarhad J. Agri. 23: 423-427.

Hussain, N., A.Z. Khan, H. Akbar, N.G. Bangash, Z.H. Khan and M. Idrees. 2007. Response of maize varieties to phosphorus and potassium levels. Sarhad J. Agri. 23: 423-427.

Ibrahim SA, Kandil H, 2007. Growth, yield and chemical constituents of corn (*Zea mays* L.) as affected by nitrogen and phosphors fertilization under different irrigation intervals. J. Applied Sci. Res. 3: 1112-1120.

Ibrahim, S.A. and H. Kandil. 2007. Growth, yield and chemical constituents of corn (*Zea mays* L.) as affected by nitrogen and phosphors fertilization under different irrigation intervals. J. Applied Sci. Res. 3: 1112-1120.

Khan, F., S. Khan, S. Fahad, S. Faisal, S. Hussain, S. Ali, A. Ali. 2014. Effect of different levels of nitrogen and phosphorus on the phenology and yield of Maize Varieties. American J. Plant Sci. 5: 2582–2590.

Mahmood, M.T., M. Maqsood, T.H. Awan, R. Sarwar and M.I. Hussain. 2001. Effect of different levels of nitrogen and intra row plant spacing on yield and yield components of maize. Pak. J. Agri. Sci. 8: 48-49.

Maqsood, M., A.M. Abid, A. Iqbal M.I. Hussain. 2001. Effect of variable rate of nitrogen and phosphorus on growth and yield of maize. J. Biol. Sci. 1: 19-20.

Masood, T., R. Gul, F. Munsif, F. Jalal, Z. Hussain, N. Noreen, H. Khan, Nasiruddin and H. Khan. 2011.Effect of different phosphorus levels on the yield and yield components of maize. Sarhad J. Agri. 27: 167.

Minjian, C., Y. Haiqui, Y. Hongkui and J. Chungi. 2007. Difference in tolerance to potassium deficiency between maize inbred lines. Plant Prod. Sci. 10: 42-46.

Oaks, A. 1994. Efficiency of nitrogen utilization in C_3 and C_4 cereals. Plant Physiol. 106: 407-414.

Ogbaji, M.I. 2003. Effects of nitrogen rates and intra row spacing on local maize in southern Guinea Savannah zone of Nigeria. J. Sustainable Agri. Environ. 5: 147-152.

Oktem, G. and A. Oktem. 2005. Effect of nitrogen and intra row spaces on sweet corn *(Zea mays* L.) ear characteristics. Asian J. Plant Sci. 4: 361-364.

Rashid, A. and K.S. Memon. 2001. Soil and fertilizer phosphorus. Soil Sci. B. Elenaand and R. Bantel (Eds). National Book Foundation, Islamabad, Pakistan. pp: 300-302.

Sharar, M.S., M. Ayub, M.A. Nadeem and N. Ahmad. 2003. Effect of different rates of nitrogen and phosphorus on growth and grain yield of maize. Asian Plant Sci. 2: 347-349.

Sharifi, R.S. and R. Taghizadeh. 2009. Response of maize (*Zea mays* L.) cultivars to different levels of nitrogen fertilizer. J. Food Agri. Environ. 7: 518-521.

Tisdale, S.C., W.L. Nelson and J.O. Beaton. 1990. Soil fertility and fertilizer elements required in plant nutrition. 4th Ed. Maxwell Macmillan Publishing, Singapore. Vet. Sci., 20: 11-15.